

ONR Graduate Traineeship Award Update

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LONG-TERM GOALS

The top-level goal of this project is to examine the physics of ambient noise in the ocean which limits the use of ambient noise correlation techniques. In addition this research should lead the PI to a Ph.D.

OBJECTIVES

Noise correlation processing extracts coherent signals from seemingly random noise data. Although this technique has been successfully used in processing ocean ambient noise data it has severe limitations due to the changing ocean environment and the spacial and temporal variability in sources. In this project we are: (1) investigating the physics of the noise processing procedure that constrains the optimum correlation, (2) attempting to understand where and how the degradation of the derived time domain Green's function (TDGF) comes about, and (3) exploit array and signal processing techniques to optimmize the signal-to-clutter (otherwise known as the 'signal-to-noise') rate of the noise correlation processing.

APPROACH

Using both computer simulations and ambient noise ocean data I have begun looking at the noise correlation processing techniques already in use. The data set used is from the Adaptive Beach Monitoring (ABM) experiment in 1995. The simulation is of the same ocean environment so the comparison between the results is easy.

This work was greatly aided by my advisor, Professor William Kuperman, and Prof. Karim Sabra (formerly of MPL, now at Georgia Tech). Prof. Sabra had previously laid much of the groundwork for this research and allowed me to build upon his suite of noise processing models.

WORK COMPLETED

During this initial work on this project I began processing of the ABM noise data and set up a computer program to simulate the noise correlation processing. The output of the simulation successfully matched the noise correlation processing of the actual data. In addition I examined the build-up and degradation over time of signal-to-clutter rate for the processed data. This allowed me to determine the optimum correlation time-length for this data, and to begin to examine the physical limitations of the noise correlation process tied with the environment within which the data is taken.

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RESULTS

The initial results for this project show that the noise correlation processing of the data accurately matches a simulation of the same ocean environment.

The optimum time to process the given data was experimentally determined by tracking the signal-to-'noise' ratio as successive time increments were added to the correlation processing time. From examining the noise characteristics at the point where the noise to clutter rate began to degrade we can correlate this deterioration with a change in the ocean noise field. Figure 1 shows the evolution of the strength of the strongest noise correlation return over time at increasing distances between hydrophones. As the distances are ranked only with regard to the distance between hydrophone pairs and regardless of physical location of individual hydrophones there is some noted variation in optimum correlation time which reflects the inhomogeneity of the noise field in the local ocean environment.

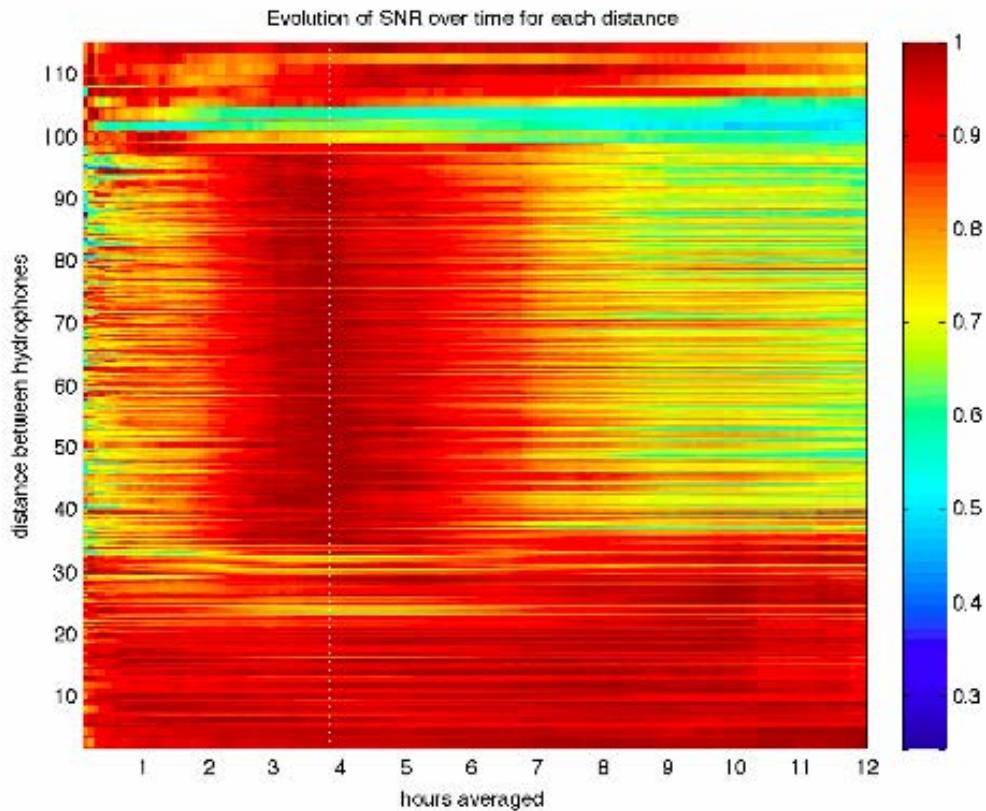


Figure 1: Evolution of the signal-to-clutter over time for increasing distances.
This figure shows the evolution and deterioration of the signal-to-clutter rate for each possible distance between hydrophone pairs (y-axis) as increasing time increments (x-axis) are averaged into the noise correlation function. The dotted white line at 3.8 hours shows the average optimal time for correlation over all the distances.

Using the optimum time determined for this data, figure 2 shows the matched noise correlation processing with the simulation for the same ocean environment. Especially significant is that the noise correlation can accurately resolve multiple arrival times and – at least for this case where the noise

environment was dominated by volumetric sources near the hydrophone array – within a scaling factor the strength of these arrivals can be related to the theoretical strength of different travel paths.

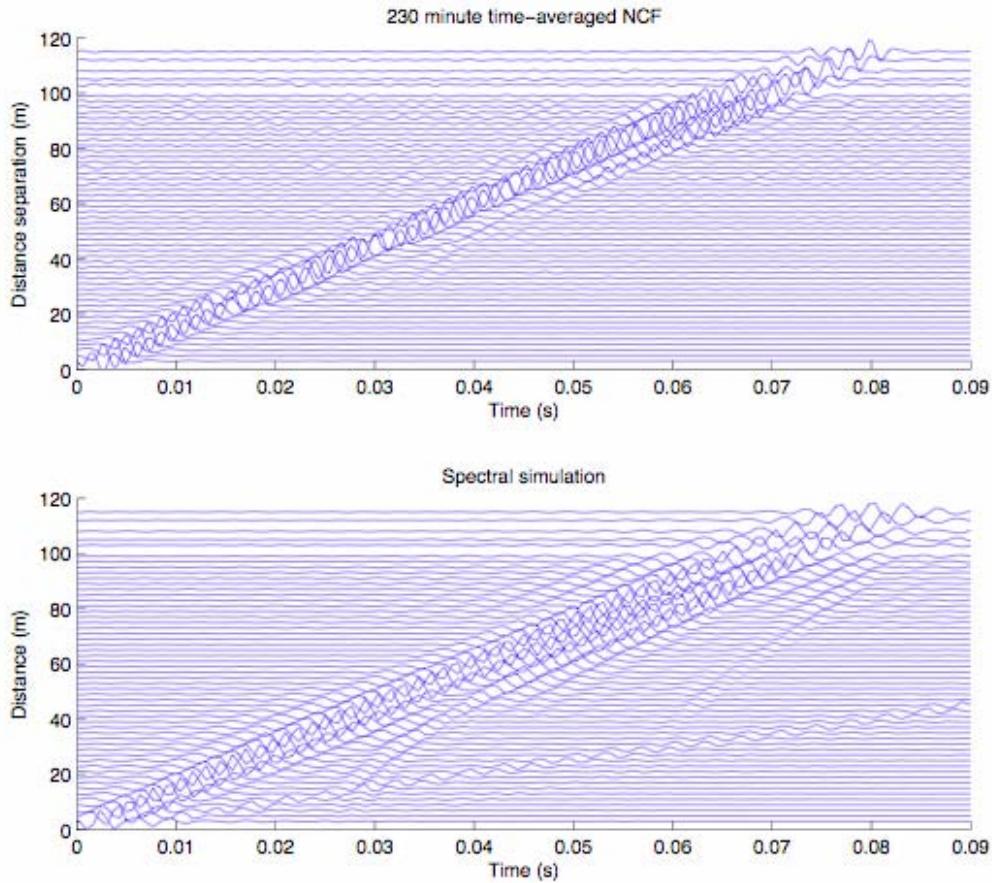


Figure 2: Comparison of the seismogram produced from the noise correlation function (NCF) processing on the ABM data (top plot) with the theoretical of the TDGF in the same environment (bottom plot). The peaks of each trace represent the arrival time (x-axis) for the sound path(s) between the hydrophone pairs at increasing separation distances (y-axis).

IMPACT/APPLICATIONS

Potential future impact for Science and/or Systems Applications is that it finds application for noise, typically rejected and not further used.

RELATED PROJECTS

This research is related to the ONR 6.1 program “Extracting Coherent Structures from High Frequency Ocean Noise.”